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(71) Applicant *(for all designated States except US)*: BOOTSMAN HOLDING B.V. [NL/NL]; P.O. Box 416, NL-2130 AL Hoofddorp (NL).

(72) Inventor; and

(75) Inventor/Applicant *(for US only)*: BOOTSMAN, Gerrit [NL/NL]; Graftermeerstraat 27, NL-2131 AA Hoofddorp (NL).

(74) Agent: ASSENDELFT, Jacobus, Hendrikus, Wilhelmus; Maartensweer 13, NL-2265 DH Leidschendam (NL).

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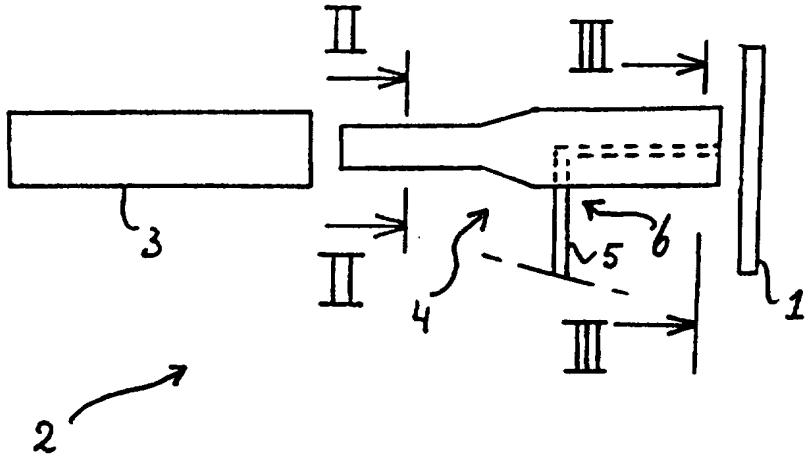
(54) Title: METHOD AND DEVICE FOR TREATING A SUBSTRATE

(57) Abstract

Method, in which a substrate is subjected to a treatment medium while energy is fed from a laser beam, and in which treatment medium is first brought in the laser beam, then fed to the substrate with the laser beam and finally comes in contact with the substrate. A hollow bundle of glass fibres is e.g. used, feeding the treatment medium within it.



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Method and device for treating a substrate.

The invention is in the field of changing the chararcter of a substrate with energy form laser light and treatment medium. More in particular, though not exclusively, the invention is concerned with locally changing the surface or the surface layer of a substrate, e.g. to make a pattern in it.

It is e.g. known, to place a substrate in a chamber with a controlled atmosphere, while projecting light onto the substrate from one or more laser sources outside the chamber, to strongly heat the surface locally. One or more compounds from the atmosphere of the chamber are selected to make a change in the character of the surface of the substrate, such that a pattern is made in or on the substrate. A drawback of this known technique is the requirement, to use a chamber with a controlled atmosphere. This chamber is inconvenient for the positioning and removal of the substrate. The chamber restricts the dimensions and the type of substrate. The chamber at least results in extreme loss of treatment medium. The chamber requires special measurements to arrive at the controlled atmosphere.

It is known as well, to feed a protection gas concentrically around the laser beam to a substrate. This requires special feed nozzles for the protection gas. On the one hand, those are relatively expensive, on the other hand they restrict the area that can be covered by the laser beam. The amount of protection gas that is active during use, is low. The protection gas can diffuse into the environment relatively easy.

The object of the invention is to solve problems of the prior art, such as one or more of the above discussed problems.

The invention therefor proposes a method according to claim 1 and a device according to claim 5. Preferred further developments are indicated in the dependent claims.

The invention is based on the recognition, that by feeding the treatment medium inside the laser beam, on the one hand there is a better protection against undemanded leakage of treatment medium into the atmosphere. On the other hand there is a larger contact area between the laser beam and the treatment

medium, such that the use of the treatment medium is more effective. The feed of treatment medium to the operating area does not obstruct the laser beam. It is found out that it is not necessary to use a seperate closed chamber, in which the substrate is treated by the treatment medium. With the invention, such closed chamber can be designed integrally with the feed element for the laser beam and the treatment medium.

According to a preferred embodiment, the laser beam is hollow. "Hollow" means here, that a core area of the laser beam carries substantially no laser energy. In stead, the treatment medium flows through said "hollow" area to the position where the laser beam strikes the substrate.

With treatment medium a gas or a fluid or a mixture of both is meant here. It can be one or more protection compounds, or one or more compounds that chemically react with the material of the substrate, of combinations of both. With that, one can e.g. "write" on the substrate, e.g. by making the substrate changing of color.

With substrate each material that is adapted for processing treatment by a laser beam and one or more treatment mediums, is meant. Several plastics like Polyvinylchloride (PVC), (poly)ethylenes and -ethenes and metals, like ferro and aluminium alloys, but ceramic materials as well, are among those materials.

The hollow laser beam can be made by using different techniques. E.g. with one or more mirrors or lenses or combinations of one or more mirrors or lenses. Or with one or more optical fibres. E.g. with a bundle of optical fibres, e.g. glass fibres, the longitudinal ends of which, facing the substrate, provided in a ring pattern. Or one or more fibres have a core area carrying substantially no laser light. Such fibre is e.g. hollow, and the treatment medium is carried through said hole.

It is of course possible, to feed in another way further medium, e.g. a protection gas, to the position where the laser beam strikes the substrate. For that purpose there is e.g. a tube outside the laser beam, carrying said further medium, and

debouching just above the substrate, and e.g. moving with the laser beam with respect to the substrate.

The invention also comprises the use without special provisions to the character of the laser beam while the possibility is provided after all, to feed the treatment medium together with the laser beam, wherein the laser beam more or less "guides" the treatment medium and the treatment medium is inside the laser beam.

According to another embodiment of the invention, measurements are taken such that the energy of the laser beam is concentrated in the outer area while a space is left in a core area with at least a substantial lower energy density.

With "laser beam" each bundle or beam of electromagnetic wave energy of preferably coherent character and with substantially parallel, diverging or converging propagation, the radiation having a wave length that is preferably within the infra-red area, is meant.

An application that has preference at this moment, is making marks on the surface of the substrate. With "marks" an image of e.g. a thing, but also characters, numbers, words, drawings, etc., is meant. For that purpose the laser beam scans the surface of the substrate according to a predetermined pattern. For that purpose the substrate is e.g. rotated and/or translated with a laser beam that is held in a fixed position. Contrary, the laser beam can be rotated and/or translated with a substrate that is held in a fixed position. E.g. by deflecting the laser beam according to a predetermined method. Or by displacement or the laser beam source. Combinations of movement of the laser beam and the substrate are feasible as well. Other methods for scanning the laser beam over the substrate will be obvious to the skilled person. While the laser beam scans the surface of the substrate, said surface of the substrate is subjected to the heat and/or the radiation from the laser beam. Depending on the material of the substrate, the influence of the laser beam itself can provide a change in the character of the surface or surface layer of the substrate. Then the treatment medium is e.g. used

to control said change. Said treatment medium is then e.g. a protecting compound, to prevent an unwanted change by virtue of the influence of one or more compounds from the surrounding environment (usually the atmosphere). It is feasible as well, that the laser beam carries out a pretreatment of the surface of the substrate, e.g. melts or heats to a convenient temperature, and the treatment medium that is fed with the laser beam, then acts on the substrate.

In stead of treatment of the surface layer, treatment of a deeper layer of the substrate is possible as well. For that purpose, e.g. two laser beams are focussed on the same point beneath the surface layer of the substrate. Treatment medium then can be fed through one of said both, or both, laser beams. The treatment medium is then used to protect the surface layer of the substrate, that is subjected to the laser beam as well, against unwanted changes.

Halogens can be used as the treatment medium as well. Other comounds are possible as well.

It will be clear to the skilled person, how to put the invention into practice. There is no need any more for a chamber, in which the substrate is subjected to a controlled environment. In fact, the laser beam locally makes such chamber. An implement is required to position the substrate. A laser beam generator is required, generating a laser beam of required character. A source of treatment gas is required. a means to feed the treatment gas together with the laser beam, according to the invention, is required. And a means to guarantee that the laser beam strikes the substrate at the predetermined position is required.

In the following a description is given of a now preferred embodiment, referring to the enclosed drawings. The drawing shows in fig. 1 a schematic side view of a device according to the invention. Fig. 2 and 3 show cross sectional views according to the lines II-II resp. III-III in fig. 1.

Fig. 1 shows a substrate that is to be treated with the device 2. This device 2 has a laser beam generator 3, a bundle of opticle fibres 4 and a feed tube 5 for treatment medium. The

substrate is mounted on a treatment table, that is moveable with respect to the device 2 in its plane, such that the laser beam can scan the substrate 1.

The bundle 4 is "solid" close to the generator 3, i.e. the seperate fibres are packed with the smallest spacing as possible into a substantial circle shaped section (refer to fig. 2). As a consequence, all energy from the generator is received by the bundle and transferred further. The shape and dimension of the bundle 4 is therefor adapted to the laser beam coming from the generator 3. More towards the substrate 1, the seperate fibres are rearranged such that a hollow core is made (refer to fig. 3). The tube 5 extends within said hole. The tube 5 is conveniently led through the bundle 4 from the outside, as will be clear to the skilled person. Based on the Gaussian energy-distribution of the laser beam, a convenient rearrangement of the seperate fibres around the tube 5 is achieved. With that, e.g. a smooth circumferential energy distribution can be met for the bundle. By way of alternative, a predetermined change in the energy distribution around the circumference of the bundle can be made. The tube 5 and the bundle 4 end relatively close above the surface of the substrate. Said distance is selected such that treatment medium, flowing out of the tube 5, substantially flows over the surface of the substrate to do its job.

The bundle 4 ends at a distance to the substrate 1 which is selected such that, preferably as a function of the flow rate and pressure of the stream coming out and one or more physical properties like viscosity, substantially all treatment medium flowing out of the bundle 4 first strikes the substrate, before leaving the laser beam, should some of the treatment medium have remained after contact with the substrate. This size of the gap can be determined by trail and error.

Apart from the embodiment as described and shown above, other alternatives according to the invention are of course possible as well. It can e.g. be taken care that the bundle 4 is substantially medium tight. Then it is no longer necessary that the tube 5 extends through the bundle 4. Or the tube 5

can end at a large distance from the substrate 1 within the bundle 4. When the bundle 4 can be flexed easily, such flexure can be used to scan the substrate with the laser beam. Depending on the embodiment, the tube 5 or the feed tube to the tube 5 must be made flexible. According to another alternative the bundle 4 can have a section according to fig. 2 over its complete length, while it is surrounded by a medium tight shell. The treatment medium can then flow to the substrate within the space between the neighbouring seperate fibres of the bundle 4. In stead of a bundle 4 with a circle shaped section, other shapes for the section can be selected. With use of glass fibre bundles for leading the laser light, the pattern of the laser light striking the substrate can e.g. be adapted by groupwise focussing light coming from the seperate glass fibres, such that areas are created on the substrate in which the laser ligth is focussed, which are alternating with areas in which the intensity of the laser light is substantially weaker. With that, a ring pattern can e.g. be made, in which the intensity of the laser energy, moving along the pattern, varies substantially. Writing by changing the color of the substrate with the aid of the treatment medium (e.g. a halogene) is a method that is alternatively independent from claim 1, that thus can possibly be carried out with a feed of treatment medium outside the laser beam. "Change of color" preferably means without substantially affecting the coherence of the substrate, i.e. without e.g. burning or carbonizing or without substantial melting.

Claims

1. Method, in which a substrate is subjected to a treatment medium while energy is fed from a laser beam, and in which treatment medium is first brought in the laser beam, then fed to the substrate with the laser beam and finally comes in contact with the substrate.

2. Method according to claim 1, wherein the laser beam has one or more holes, running in its lengthwise direction, and treatment medium is fed to the substrate through one or more of said holes, and possibly wherein the laser beam bridges a gap to the substrate, which gap has dimensions such that substantially no treatment medium leaves the laser beam, before it strikes the substrate.

3. Method, possibly according to any of the proceeding claims, wherein the surface or the surface layer of the substrate is treated with a suitable treatment medium to change one or more of its properties, and possibly wherein the laser beam is moved over the substrate according to a predetermined pattern to make a mark on the substrate, preferably by feeding treatment medium to make a color change of the substrate.

4. Method according to any of the proceeding claims, which is carried out in free space.

5. Substrate treatment device, with a substrate mount, a laser beam generator and a source of treatment medium, wherein the laser beam generator is adapted to generate a laser beam such that treatment medium from the source of treatment medium can be guided to the substrate by the laser beam, and possibly wherein a hollow laser beam can be generated, and there are means to bring treatment medium into the hollow laser beam and guide it to the substrate with the laser beam.

6. Device according to claim 5, wherein there are one or more optical fibres that are adapted to develop the prefered laser beam, and possibly wherein there are one

or more holes in lengthwise direction of said one or more fibres, in which a feed of treatment medium debouches.

7. Device according to claim 6, wherein several of those fibres are positioned in a ring pattern with their longitudinal ends facing the substrate, to generate a hollow laser beam.

8. Device according to claim 6 or 7, wherein the bundle of optical fibres is designed to be substantially medium tight, such that the treatment medium can be led through substantially leak free.

9. Device according to claim 5, possibly in combination with one of the claims 6 or 7, wherein one or more optical elements, such as lenses or mirrors, are positioned to generate the preferred laser beam.

10. Device according to any of claims 5 - 9, wherein there are means to scan the substrate with the laser beam according to a predetermined pattern.

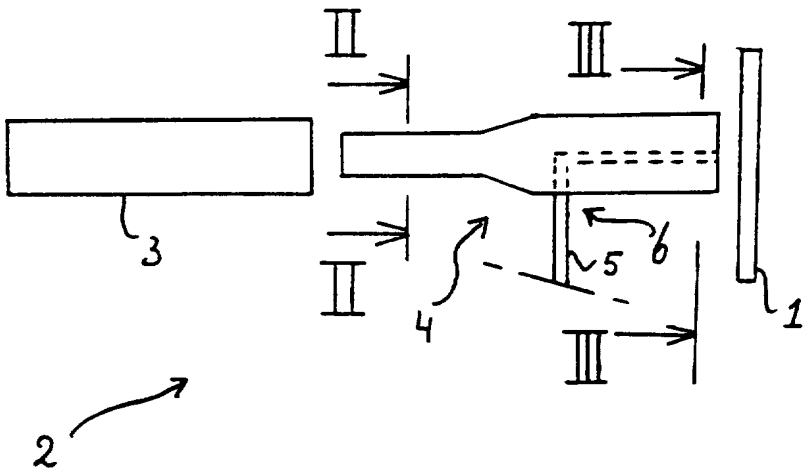

Fig 1

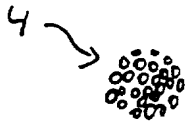

Fig 2

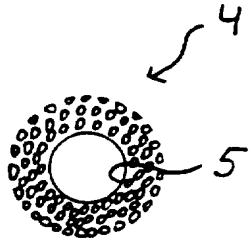

Fig 3

INTERNATIONAL SEARCH REPORT

Inter nal Application No
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A. CLASSIFICATION OF SUBJECT MATTER
IPC 6 B23K26/14

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B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
IPC 6 B23K

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

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C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category *	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	DE 39 06 571 A (FESTO KG) 6 September 1990 see the whole document ---	1-8
X	WO 93 19888 A (CAULDRON LP ;ENGELSBERG AUDREY C (US); DEHAIS JOSEPH A (US)) 14 October 1993 see page 15, line 27 - page 16, line 10; figures 5,6,8,10,11 ---	1-8
X	PATENT ABSTRACTS OF JAPAN vol. 008, no. 197 (M-324), 11 September 1984 & JP 59 087994 A (ISHIKAWAJIMA HARIMA JUKOGYO KK), 21 May 1984, see abstract --- -/--	1-4

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Information on patent family members

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